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Research

Journal of Dental Science, Oral and Maxillofacial Research

The efficacy of a none peroxide bleaching agent: In vivo study

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Received: November 09, 2023 | **Published:** March 05, 2024

Abstract

Purpose: The aim of this clinical study was to evaluate tooth color change and surface topography after exposure to peroxide and none peroxide in-office tooth whitening systems.

Methods: Twenty subjects were enrolled according to the study inclusionary criteria. Color measurement was made using an intraoral colorimeter (Shade Star, Dentsply, UK) Impressions for the upper arches were taken immediately before bleaching. Ten subjects were treated with 25% hydrogen peroxide bleaching agent (Zoom2 kit, Discus Dental) for 45-min exposures of bleach, on three sequential sessions of 15 mins each. The other ten subjects received none peroxide bleaching agent (Gentle Bright plus, LumaLite) for 15-min exposures of bleach, on three sequential sessions of 5mins each. For both bleaching techniques adjunctive light was used (ZoomAP, Discus Dental). Color measurements and upper arch impressions were immediately after bleaching. Data was analyzed using Mann-Whitney U-test and Wilcoxon signed-rank test at the 0.05 level of significance. Epoxy resin replica were obtained from the impressions and examined under scanning electron microscope (SEM) to study the changes in enamel surface morphology.

Results: Instrumental color measurements revealed that both peroxide and none peroxide based bleaching agents induced significant color change at p=0.049 and 0.046 respectively. However no significant difference was found between treatment with peroxide based ΔE_{ab}=7.5 and none peroxide ΔE_{ab}=7.75 (p=.617). SEM results revealed that none peroxide bleaching agent induced alteration in the enamel surface morphology.

Conclusions: Within the limitations of this study, peroxide and non peroxide based systems were equally effective in tooth whitening. However, none peroxide bleaching agent induced alteration in the enamel surface topography compared to the peroxide alternative.

Introduction

As the standards of living and the dental health awareness have been improved, esthetic dentistry has become essential in daily practice. Pretty smile with non-discolored teeth has been very essential to patients of all ages and levels. Vital tooth bleaching is one of the techniques that are used for managing tooth discoloration. It is considered to be more conservative in comparison with other restorative treatments such as laminate veneers or full coverage restoration.[1]

Commercially available tooth bleaching systems mainly based on hydrogen peroxide or one of its precursors, as carbamide peroxide. These are activated by heat and / or light.[2] However, concerns have been expressed over the potential side effects of the use of peroxide based bleaching agents. They include tooth sensitivity, gingival irritation and alteration in the topography of the tooth.[3-5]

As a consequence of these drawbacks a non-peroxide based bleaching systems are introduced. It is based on chlorite dioxide that was used for decades as a disinfectant for food and water. Its safety and efficacy has been well established. Previous examinations on sodium-chlorite based bleaching agents have concluded its effect on the mechanical and physicochemical characteristic of enamel.[6-9] However its clinical bleaching efficacy was not elucidated.

The bleaching efficacy is commonly evaluated by the comparison with a tooth shade guide. Measuring shade visually has been characterized by many difficulties: metamerism, suboptimal color matching conditions, tools and method as well as the receiver's age fatigue, mood and drugs/medications.[10] Today's shade-selection technologies have been developed in an effort to increase the success of color matching, communication, reproduction and verification in clinically, and, ultimately, to increase the efficiency of esthetic restorative work within any practice. Furthermore, it eliminates the drawbacks experienced on color evaluation, even by the most trained individuals. Instruments for clinical shade-matching include spectrophotometers, colorimeters and imaging systems.[11,12] The use of these equipment can reduce the subjective nature and environmental influence on the color perception.[13] The American Dental Association (ADA) Acceptance Program Guidelines recommends a "value-ordered" shade guide for establishing bleaching efficacy. For professional in-office tooth bleaching products, these guidelines call for documentation of color changes ≥5 color change units (ccu) to indicate efficacious bleaching treatment; where 1 ccu = 1 shade guide unit sgu = $1\Delta E^*_{ab}$.[14]

The target of our study was to examine the clinical bleaching efficacy of the peroxide and non-peroxide based systems and to analyze their effects on the surface topography.

Citation: Elhoshy AZ, Yassen AA, Elkassas DW. The efficacy of a none peroxide bleaching agent: In vivo study. *J Dent Maxillofacial Res.* (2024);7(1): 1‒4. DOI: 10.30881/jdsomr.00072

Materials and methods

Inclusion and exclusion criteria

A total of 20 subjects were registered in this study, and a total of 40 teeth were inspected (two upper central incisor). For inclusion, teeth to be bleached in all patients should be lesions free, between 18 and 25 years, and willingness to stop using tobacco product, coffee, tea, soda and other beverages that may cause tooth discoloration during the study. The exclusion criteria involved patients whose teeth had been previously bleached, or with a shade lighter than A2, stated tooth sensitivity, with distinguished intrinsic staining (tetracycline, fluorosis), existing dental restorations in teeth to be bleached, currently undergoing treatment for caries, gingivitis or periodontitis, current use of Chlorhexidine or Listerine mouth rinses, or who established any medical or dental status (gingival inflammation) considered by examiners to place the patient at increased health risk or to impact patient's ability to participate in study. After discussing the trial, patients were required to sign an informed consent form. Enrolled patients were further instructed to avoid any non-study dentifrices or tooth whitening products for the time of the study.

Study design

Study subjects were received a professional prophylaxis at least two weeks before the study and were motivated to maintain their oral hygiene by tooth brushing twice a day with tooth paste (Sensodyne F, Stafford- Miller Ltd., Welwyn Garden City, UK) and dental flossing once a day. They were divided into two groups according to the bleaching materials used either peroxide-based gel, composed of 25% hydrogen peroxide, (P. Zoom2 kit, Discus Dental, Culver City, CA, USA, sku product number #2642) or non peroxide based gel composed of phosphoric Acid, sodium chlorite, and sodium carbonate in concentrations of 0.5% to 2.3%, (NP. Gentle Bright Plus, lot number item # 210064-P). Protective lip cream was applied. Isolation was done with a light-cured resin barrier for gingival protection and then the bleaching gel was applied according to the manufacturer instructions. Special glasses were worn by patients when the chair side activating lamp was switched on. This light was a sodium-free, 25 W, short- arc halide lamp, emitting between 350 and 600 nm. (Zoom AP, Discus Dental) was applied.

For the peroxide based bleaching agent, teeth to be bleached were pre-treated with an aqueous alkaline solution (Zoom2 starter swab) from the kit. The pre-treatment solution and the bleaching gel were placed and repeated for three individual 15-min cycles for a total exposure time of 45 min. Meanwhile for the none peroxide bleaching agent, the bleaching gel was applied on three sequential sessions of 5mins each for a total exposure time of 15 min. Between applications, the components were removed by suction.

Color evaluation

The color was recorded prior to the bleaching process and immediately after bleaching using a contact-type intraoral colorimeter (Shade Star, Dentsply, UK). It was calibrated according to the producer's instructions and the readings were taken from the middle middle one third of all the teeth. In this device the color is documented according to Vita lumen shade guide tabs. Color difference metric values were compared to the corresponding Vitapan Classical shade.

Descriptive statistics were acquired and data were judged using Wilcoxon Signed Ranks Tests at the 0.05 level of significance.

Scanning electron microscope SEM

A polyvinyl siloxane impression material impression was taken (Impregum, 3M Espe, USA) before, immediately after the bleaching. The impression was rinsed, disinfected, dried, and filled with a vacuum-mixed epoxy resin (Araldit D, Ciba-Geigy GmbH, Wehr, Switzerland). Epoxy resin replicas obtained from the impressions taken before bleaching were used as negative controls. The epoxy resin was treated overnight at 65°C in a curing oven. The epoxy cast was removed from the impression, mounted on a specimen stub, sputter coated with gold and examined under the SEM (Model Philips XL 30, USA) at X 500 and X 2000 magnification with accelerating voltage to 30 K.V. to study the changes in enamel surface topography.[15]

Statistical analysis

The shade guide was sorted by value order from lightest to darkest as determined by the manufacturer, and a corresponding position number assigned to allow statistical analysis (Table 1). Data were presented as mean, median and standard deviation (SD) values. Mann-Whitney U test was used to compare between the two treatments. Wilcox on signed-rank test was used to study the changes after bleaching with each treatment. The significance level was set at $P \leq 0.05$. Statistical analysis was made with SPSS 16.0® (Inc., Chicago, IL, USA.) (Statistical Package for Scientific Studies) for Windows.

Table 1 Vita lumen shade tabs arranged in order of increasing value and the position value ascribed

Vita tab	B1	A1	B2	D2	A2	C1	C2	D4	A3	D3	B3	A3.5	B4	C3	A4	C5
Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Results

Color evaluation

Table 2 indicates the mean and Standard deviation (SD) values for peroxide and none peroxide groups. The results showed that there was no statistical significant difference between both peroxide and none peroxide bleached before and after bleaching at P = 0.655 and 0.647 respectively. Also there was no statistically significant difference between shade transitions in the two groups at P=0.617. Therefore, the two techniques were equivalent in their bleaching efficiency. However, both techniques either non-peroxide or peroxide based were capable of inducing a statistical significant decrease in shade position at P=0.046 and 0.049 respectively.

Table 2 Comparison between the two groups as regards shade positions before and after treatment and position change

	Peroxide based bleaching agent		None peroxide based bleaching agent		*P*-value
	Mean	SD	Mean	SD	
Before	9.75	1.7	9.25	2.1	0.655
After	2.25	1	2	0.8	0.647
Shade transition (Change)	7.50	1	7.75	1	0.617
P-value	0.046*		0.049*		

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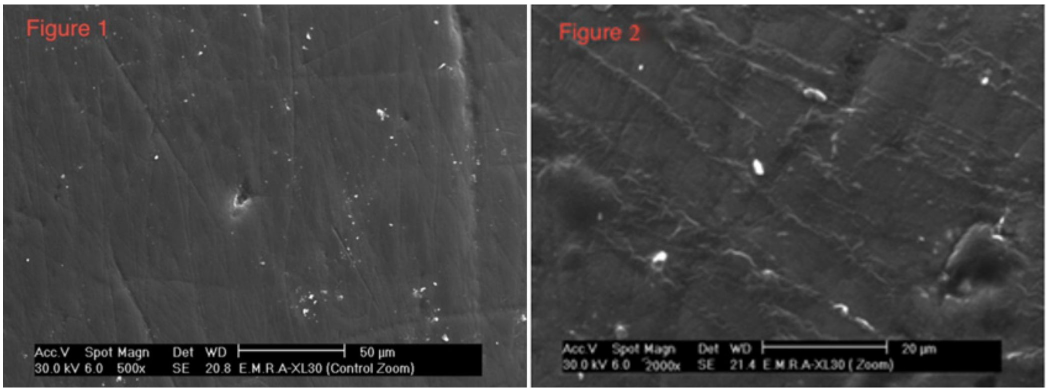
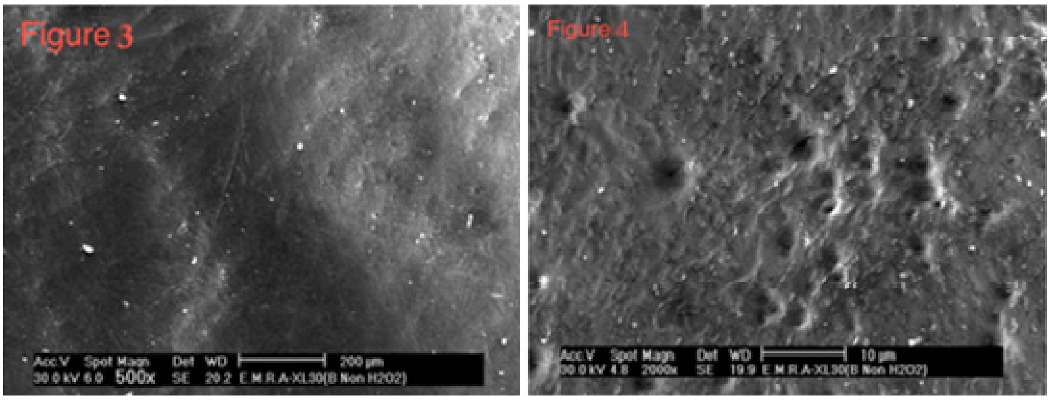
Scanning electron microscope results

Figure 1 and Figure 3 reveal unbleached enamel. The surface was not completely smooth, however the aprismatic surface layer was uniform. Pores and superficial irregularities, such as grooves could be observed, on some of the control samples. Replica representing teeth treated with peroxide based bleaching agent showed depressions which seem sometimes deeper, generating a more variable aspect of the enamel surface (Figure 2). This aspect suggested an increase in the enamel porosity, as compared to the control samples. However, areas of depression were observed sometimes in the control samples. Therefore it was found that no enamel surface changes or minimal changes occurred in the peroxide group. On the other hand, the non peroxide based bleaching agent showed numerous cracks, which appeared in the figures as black irregular fringes with further increase in enamel surface porosity. This findings denoted alterations of the prismatic structure of the enamel.



Figures 1,2 Repesesnt SEM of enamel surface topograpgy for both unbleached groups and for those bleached with peroxide based bleaching system.



Figures 3,4 Repesesnt SEM of enamel surface topograpgy for both unbleached groups and for those bleached with none peroxide based bleaching system.

Discussion

Bleaching effect of both peroxide and non peroxide based bleaching agents was proved in this study by using an intraoral colorimeter. As subjective determination of tooth color is questioned by high variability. The advantage of objective color determination in the current study is exclusion of all defeating factors and the generation of precisely and objectively evaluated data. It eliminates the possibility of visual shade matching errors.[16,17]

The bleaching groups of the current study were balanced for baseline tooth color and age. The more yellow the teeth at base line and the younger the age of the sujectes enrolled in the study, the better the outcome of tooth bleaching. The analysis by Glerlach and Zhou demonstrated a significant relationship between the subject's age and the magnitude of bleaching response.[18]

For professional in-office tooth bleaching products, color changes ≥5 color change units (ccu) indicate efficacious bleaching treatment; where 1 ccu = 1 shade guide unit (sgu)=1ΔE_{ab}. The results of our present analysis revealed that both bleaching systems used are efficient, as the peroxide based bleaching agent showed 7.5 and the none peroxide 7.75 ccu. This finding confirmed the results of a previous in vivo-studies.[19-22] Tavares et al, found that 15 % hydrogen peroxide gel produced 8.35 shades transition mean while Papathanasiou et al, found that 35 percent hydrogen peroxide gel produced 7.21 shades transition.

Bleaching effect induced with the peroxide based bleaching system could be attributed to the known theory of the breakdown of peroxide into free radicals which subsequently react with the large pigment molecules, transforming them into smaller, less pigment molecules.[6]

Meanwhile the effect induced by the none peroxide based on sodium chlorite ($NaClO_2$) activated by an acid.[7,8] Sodium chlorite is known as a bleaching agent in paper and textile industry by freeing a small amount of ClO2 in the presence of acid: $5ClO_2^- + 4H^+ \; 4ClO_2 + 2H_2O + Cl^-$[7,9]. As an oxidant, chlorine dioxide readily attacks reducing substances, such as organic materials, primarily by a one-electron pathway: $ClO_2 + e^- \; ClO_2^-$.[23] To serve as a bleaching agent, sodium chlorite must be combined with an acid such as citric acid or phosphoric acid, which might have enhanced the bleaching effect. With both bleaching systems supplementary light was used, which might in turn has enhanced the bleaching effect. It has been shown that chromophoric dispersed organic matter (CDOM) present in natural waters can undergo photolysis by exposure to UV radiation leading to the formation of hydrogen peroxide. It is plausible that

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endogenous dentinal water exposed to UV radiation can lead to the formation of additional hydrogen peroxide and thus potentiate the bleaching effect.[21]

Differences in bleaching agent, methods and instruments used for judgment of color changes, and characteristics of the bleaching lights (irradiance and spectral distribution) all add to the confusion correlated with this topic.

Despite equal efficiency proved by both bleaching systems they induced remarkable difference on enamel surface topography. The none peroxide based bleaching system has a relatively low pH-values which could in turn has soften enamel and induced surface changes.[24] Further more that it contains phosphoric acid in its composition. The 37% phosphoric acid is used in dentistry for etching the enamel and dentine in order to improve the adhesion of the composite resins. It generates a rough surface, due to the selective dissolution of apatite crystals from the enamel prisms.[25] Therefore bleaching products based on sodium chlorite are potentially hazardous for dental enamel.

This observation is in agreement with Wang et al[9] whom found a distinctly different effect of the peroxide-and non-peroxide-based bleaching systems on dental enamel: as the chlorite-based whitening product considerably affected the structure and chemistry of dental enamel.

Conclusion

Application the bleaching agents should be critically weighed up, keeping in mind the physical, physiological and patho-physiological effects. Although both products proved equal bleaching efficiency the none peroxide based altered the enamel surface tremendously.

Further studies should be carried out to study the relapse tendency of teeth bleached with none peroxide based bleaching agent.

Acknowledgments

None.

Conflicts of interest

None.

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